FINAL BASELINE HUMAN HEALTH RISK ASSESSMENT

VB/I70 SUPERFUND SITE

October 31, 2001

Figure 2-5
CHEMICAL FORMS OF ARSENIC IN SITE SOILS

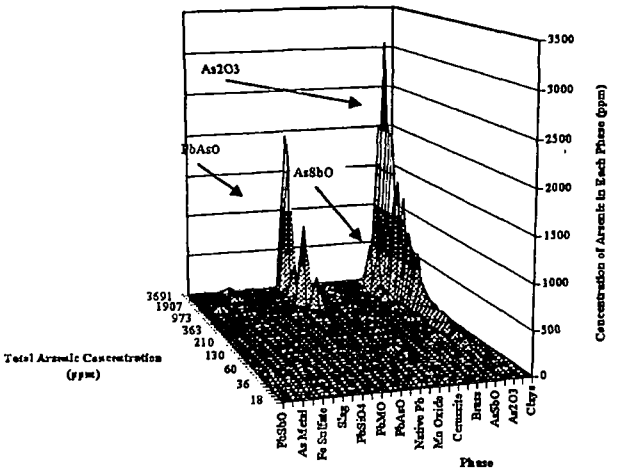


Figure 2-6
CHEMICAL FORMS OF LEAD IN SITE SOILS

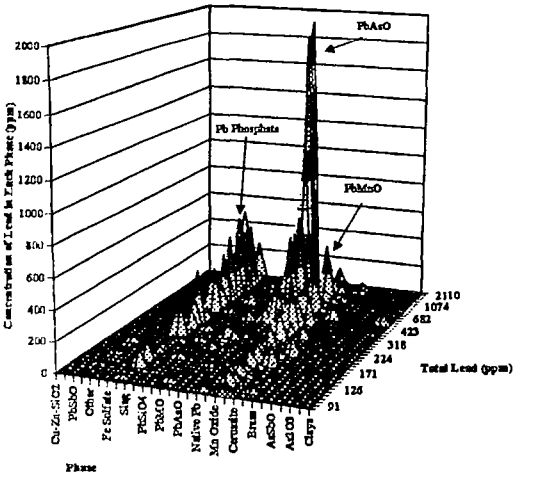


FIGURE 2-7 – PANEL A
DISTRIBUTION OF PROPERTY MEAN ARSENIC CONCENTRATIONS IN BULK SOILS

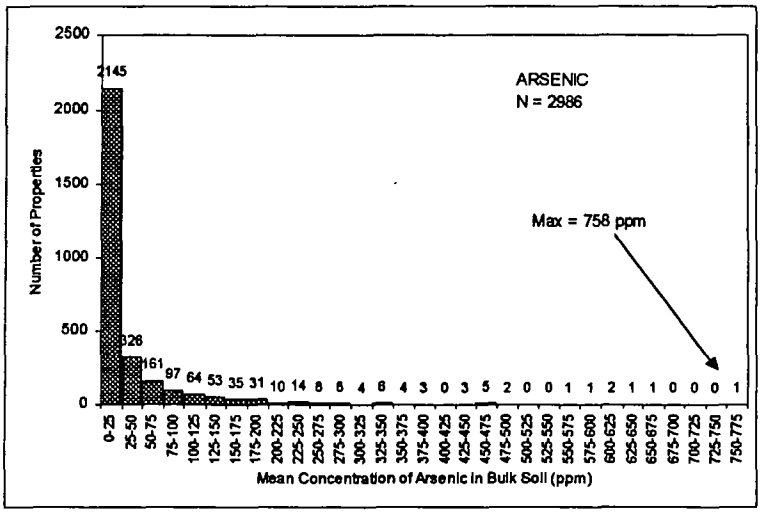
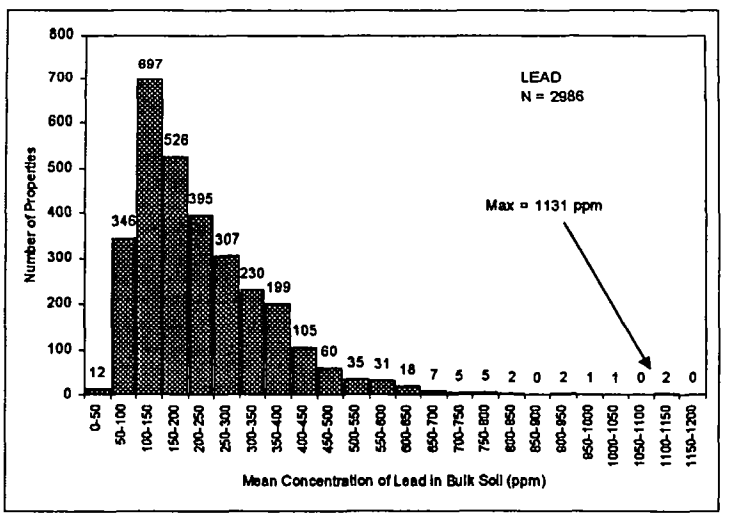
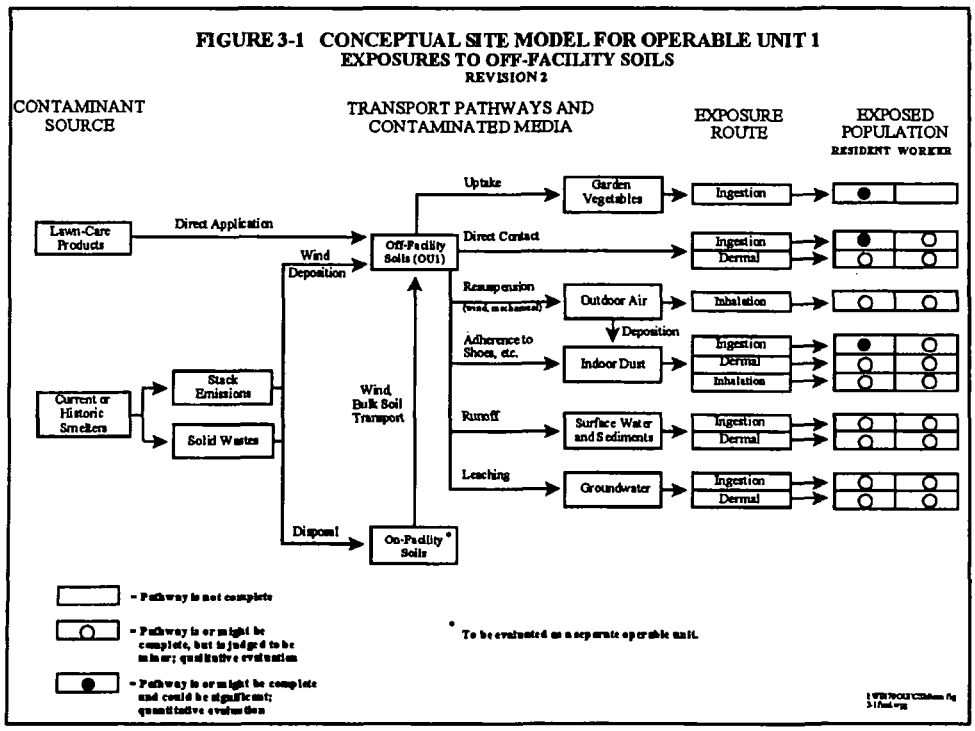


FIGURE 2-7 – PANEL B
DISTRIBUTION OF PROPERTY MEAN LEAD CONCENTRATIONS IN BULK SOILS





RISKS FROM EXPOSURE TO ARSENIC

- Cancer Risk from Chronic Exposure
  1. Soil plus Dust
  2. Garden vegetables
  3. Total Risk
- Non-cancer Risk from Short-term Exposure to Soil

CANCER RISKS FROM SOIL INGESTION

For chronic exposure, EPA assumes that a resident is exposed to the average concentration of arsenic over the entire yard.

EPA recommends the use of the **95% upper confidence limit of the arithmetic mean concentration** over the yard as the exposure point concentration or EPC.

DISTRIBUTION OF PROPERTY ARSENIC EXPOSURE POINT CONCENTRATIONS (EPCs) IN PHASE 3 SOILS

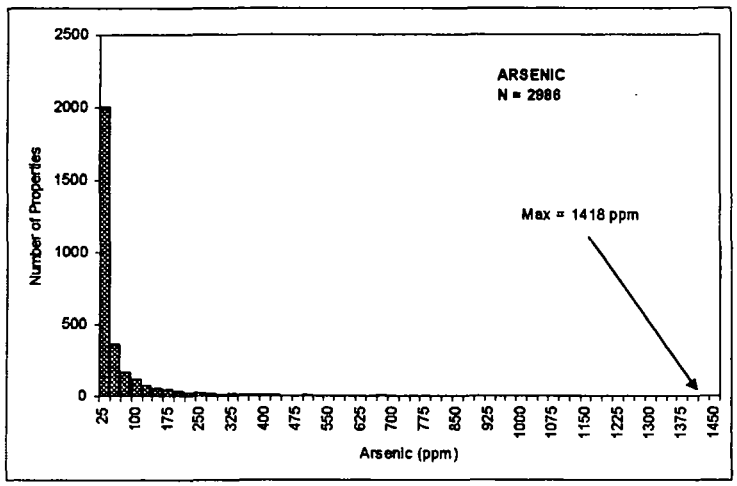
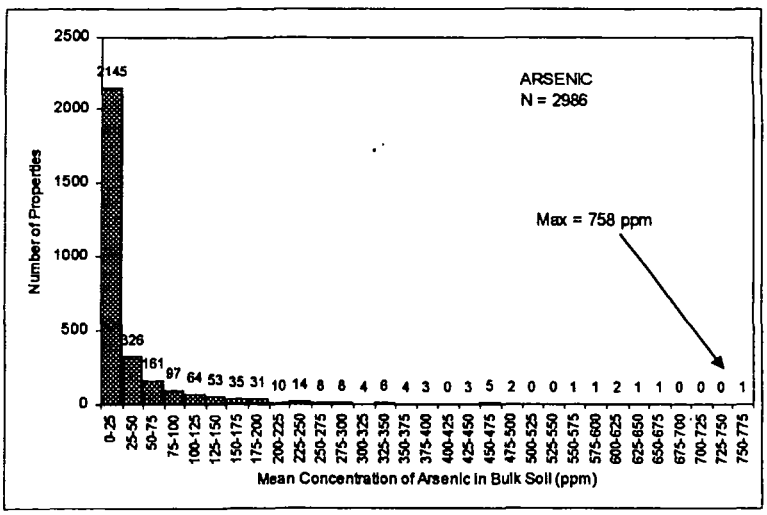


FIGURE 2-7 – PANEL A DISTRIBUTION OF PROPERTY MEAN ARSENIC CONCENTRATIONS IN BULK SOILS



Relationship between yard average and Exposure Point Concentration (EPC)

Based on the Phase III investigation, the typical ratio of the EPC to the yard average is 1.4

Relationship between arsenic in the bulk fraction and fine fraction

Results from the Phase III investigation were combined with those from the Physical-Chemical Characterization study

Arsenic concentration in the fine fraction is about 21% higher than in the bulk fraction

Chronic and subchronic exposures are suspected to be associated mainly with the fine fraction of soil.

The value for EPC is adjusted to account for the enrichment of arsenic in the fine fraction compared to the bulk fraction

EPC = 1.21 x EPC (bulk)

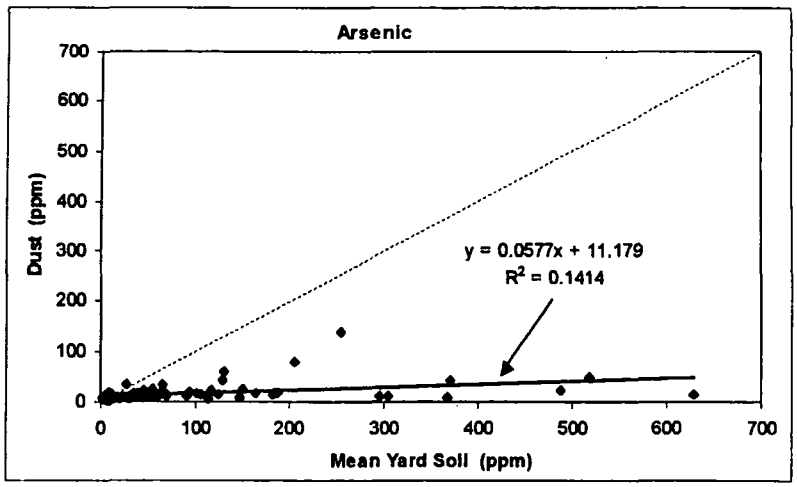
RME Exposure Parameters

	Child	Adult
Soil ingestion	200 mg/day	100 mg/day
Body weight	15 kg	70 kg
Exposure frequency	350 days/year	350 days/year
Exposure duration	6 years	24 years
Averaging time: 70 years (cancer)	30 years (non-cancer)	

Site Specific Relationship Between Outdoor Soil and Indoor Dust

- Arsenic: Dust = 0.06 Soil + 11

FIGURE 2-9 – PANEL A
RELATION BETWEEN ARSENIC CONCENTRATIONS IN INDOOR DUST AND BULK YARD SOIL



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SOIL-DUST RELATIONSHIPS AT OTHER USEPA REGION VIII SITES

Site	Slope (ppm in dust per ppm in yard soil)	
	Arsenic	Lead
Anaconda	0.31	
Bingham Creek		0.43
Butte		0.24
Deer Lodge	0.001	-0.01
East Helena		0.88
Flagstaff/Davenport		0.06
Midvale OU1	0.03	0.04
Leadville	0.1	0.33
Murray Smelter	0.17	0.19
Sandy City		0.13
Sharon Steel		0.76

Total intake of soil is assumed to be composed of 45% soil and 55% dust.

$$F_s = 0.45$$

When concentration of a contaminant in dust is substantially lower than the concentration in yard soil, the value of F_s is important.

Arsenic Toxicity Values

Toxicity Factor	Value	Source
Chronic RfD	0.0003 mg/kg/day	IRIS 2000
Oral Slope Factor	$1.5(mg/kg/day)^{-1}$	IRIS 2000

EPA performed a study on the relative bioavailability (RBA) of arsenic in soils from VB/I70

RBA can be used to adjust the Reference Dose and Slope Factor :

$$\mathbf{RfD_{adj} = RfD / RBA}$$

$$\mathbf{SF_{adj} = SF \times RBA}$$

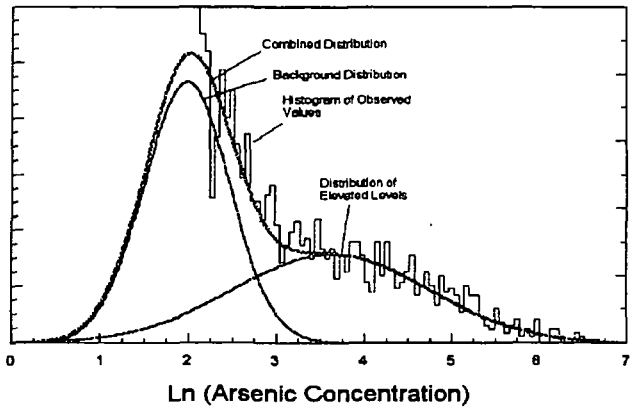
REVISED RBA DATA FOR ARSENIC

Test material	OLD	NEW
TM-1	0.37	0.35
TM-2	0.43	0.45
TM-3	0.37	0.36
TM-4	0.58	0.21
TM-5	0.18	0.18
Mean	0.39	0.31
95% UCL	0.52	0.42

TABLE 4-1
ESTIMATED CANCER RISK FROM ARSENIC IN SOIL AND DUST

Neighborhood	Number of Properties Evaluated	Number and Percent of Properties Within the Specified Risk Range							
		CTE Cancer Risk				RME Cancer Risk			
		<=1E-05	2E-05 - 1E-04	2E-04 - 1E-03	>2E-03	<=1E-05	2E-05 - 1E-04	2E-04 - 1E-03	>2E-03
Clayton	902	858	44			479	385	38	
		95%	5%			53%	43%	4%	
Clio	796	772	24			344	429	23	
		97%	3%			43%	54%	3%	
Elyria	59	58	1			17	41	1	
		98%	2%			29%	69%	2%	
Gibsonville	63	61	2			25	36	2	
		97%	3%			40%	57%	3%	
Swansea	1166	1132	34			610	528	28	
		97%	3%			52%	45%	2%	
All Neighborhoods	2986	2881	105			1475	1419	92	
		96%	4%			49%	48%	3%	

FIGURE 4-3
DISTRIBUTION OF ARSENIC VALUES IN PHASE III SOILS



Cancer risks from naturally occurring levels of arsenic range from about 1 E-06 for an average person to about **1 E-05 for an RME person**

TABLE 4-2
ESTIMATED CHRONIC NONCANCER RISK FROM ARSENIC IN SOIL AND DUST

Neighborhood	Number of Properties Evaluated	Number and Percent of Properties Within the Specified Risk Range							
		CTE Hazard Quotient				RME Hazard Quotient			
		<=1	2-5	6-10	>=11	<=1	2-5	6-10	>=11
Clayton	902	901	1	–	–	895	7	–	–
		100%	0.1%	–	–	99%	0.8%	–	–
Cole	796	796	0	–	–	786	10	–	–
		100%	0%	–	–	99%	1.3%	–	–
Elyria	59	59	0	–	–	59	0	–	–
		100%	0%	–	–	100%	0%	–	–
Globeville	63	63	0	–	–	63	0	–	–
		100%	0%	–	–	100%	0%	–	–
Swansea	1166	1166	0	–	–	1163	3	–	–
		100%	0%	–	–	100%	0.3%	–	–
All Neighborhoods	2986	2985	1	–	–	2966	20	–	–
		100%	0%	–	–	99%	0.7%	–	–

CANCER RISK FROM GARDEN VEGETABLES

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EXPOSURE PARAMETERS FOR RESIDENTIAL INGESTION OF GARDEN VEGETABLES

Parameter	CTE	RME
EPC (inorganic)	0.6*EPC(total)	0.6*EPC(total)
IR (kg wet weight/kg body wt/day)	4.92E-04	5.04E-03
Loss factor	0.86	0.86
EF (days/yr)	350	350
ED (years)	9	30
AT (noncancer effects) (days)	9*365	30*365
AT (cancer effects) (days)	70*365	70*365

REVISIONS IN RISK ESTIMATION METHOD

- Adjust for fraction of total arsenic that is inorganic

  C(inorganic) = C(total) * 0.6

- Adjust for preparation loss

  IR(adjusted) = IR(raw) * 0.86

REVISED RISK ESTIMATES FOR GARDEN VEGETABLES FROM 19 SAMPLED PROPERTIES

Property Number	Neighborhood	DF	EPC (based on inorganic arsenic) (a)	Chronic Noncancer Risk		Lifetime Cancer Risk	
				CTE	RME	CTE	RME
1	CLAYTON	1/10	3.2E-03	4E-03	4E-02	2E-07	8E-06
2	CLAYTON	0/1	2.5E-03	3E-03	3E-02	2E-07	7E-06
3	CLAYTON	0/1	2.6E-02	4E-02	4E-01	2E-06	7E-05
4	CLAYTON	3/6	3.3E-02	4E-02	5E-01	3E-06	9E-05
5	CLAYTON	1/2	1.2E-02	2E-02	2E-01	9E-07	3E-05
6	CLAYTON	12/12	3.3E-01	4E-01	[illegible]	3E-05	[illegible]
		11/11 (b)	1.3E-01	2E-01	[illegible]	1E-05	[illegible]
7	CLAYTON	0/2	9.6E-03	1E-02	1E-01	7E-07	3E-05
8	COLE	1/2	4.0E-02	5E-02	6E-01	3E-06	1E-04
9	COLE	1/2	1.1E-03	1E-03	1E-02	8E-08	3E-06
10	COLE	1/1	1.2E-03	2E-03	2E-02	9E-08	3E-06
11	COLE	4/6	1.2E-01	2E-01	[illegible]	1E-05	[illegible]
12	COLE	4/4	4.4E-02	6E-02	6E-01	3E-06	1E-04
13	COLE	3/9	2.0E-02	3E-02	3E-01	2E-06	5E-05
14	COLE	3/3	1.2E-02	2E-02	2E-01	9E-07	3E-05
15	COLE	0/4	1.9E-02	3E-02	3E-01	1E-06	5E-05
16	COLE	1/1	1.2E-02	2E-02	2E-01	9E-07	3E-05
17	SWANSEA/ELYRIA	0/2	2.0E-03	3E-03	3E-02	2E-07	5E-06
18	SWANSEA/ELYRIA	1/1	8.7E-04	1E-03	1E-02	7E-08	2E-06
19	SWANSEA/ELYRIA	1/3	2.9E-03	4E-03	4E-02	2E-07	8E-06

Combining Risks from Garden Vegetables and Soil

FIGURE 2-11 – PANEL A
RELATION BETWEEN ARSENIC IN GARDEN SOIL AND YARD SOIL

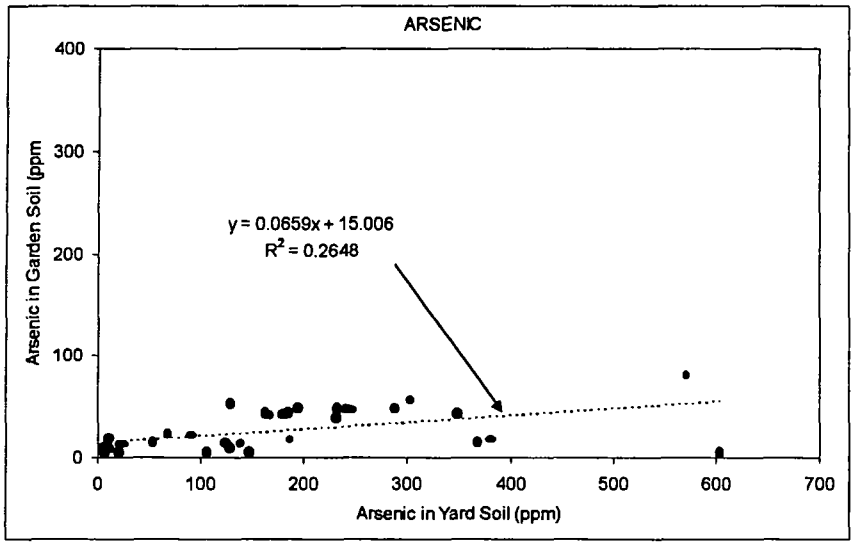
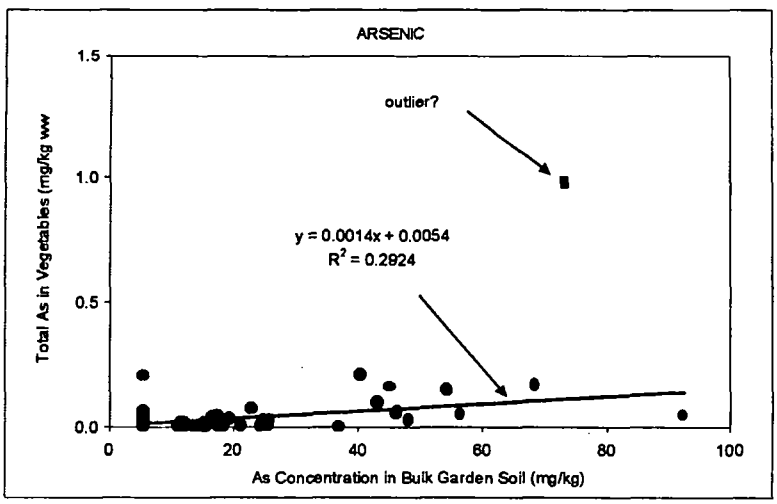


FIGURE 2-10 – PANEL A
RELATION BETWEEN TOTAL ARSENIC IN GARDEN VEGETABLES AND GARDEN SOIL



APPROACH

Perform calculations at all 2986 properties

Use site-specific data (concentration in yard soil) to estimate concentrations in garden soil and in garden vegetables

Site-Specific Relationships

- Garden soil-Garden Vegetable Relationship

  $C(veg) = C(veg)0 + Ksv*C(garden)$

- Yard Soil-Garden Soil Relationship

  $C(garden) = C(garden(0) + Ksg*C(yard\ soil)$

Summary of Predicted Cancer Risks

- RME risks are **greater than 1/10,000** at **99** properties (>0.01% chance of cancer)
- RME risks are between 1/100,000 and 1/10,000 at 1954 properties ($\leq$ 0.01% chance of cancer)
- RME risks are less than or equal to 1/100,000 at 933 properties ($\leq$ 0.001% chance of cancer)

Summary of Predicted Cancer Risks (cont.)

- For the people with **average exposures** (the "central tendency" there are **no properties where risks exceed 1/10,000**

Summary of Predicted Chronic Non-Cancer Risks

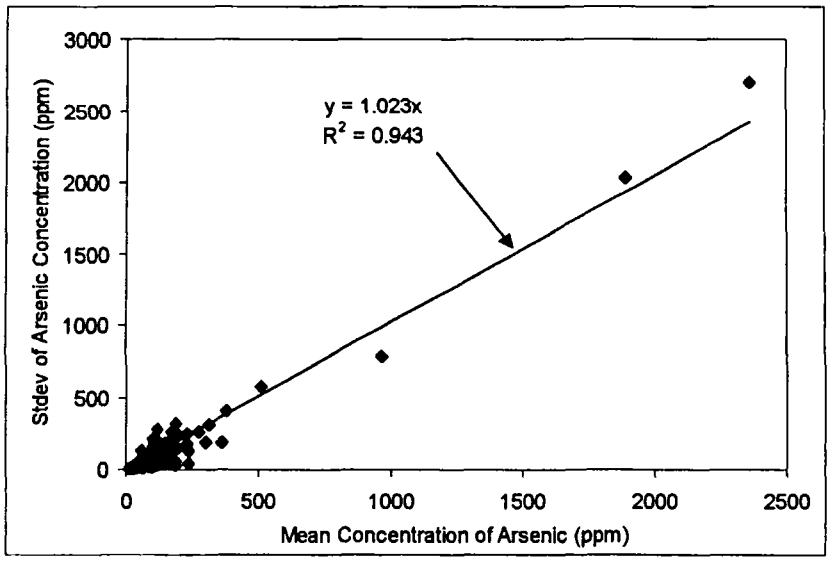
- For RME scenario, there are **20 properties** where risks are unacceptable.
- At all 20 properties, the RME cancer risk is also greater than 1/10,000
- If cancer risk above 1/10,000 is addressed, chronic non-cancer risk is addressed

Summary of Predicted Chronic Non-Cancer Risks (cont.)

- For CTE scenario, there is **1 property** where risks are unacceptable.

EVALUATION OF SHORT-TERM NONCANCER RISK

FIGURE 4-2
COEFFICIENT OF VARIATION IN YARD SOIL GRAB SAMPLES



During a 1-3 month (summertime) exposure period, a child might play in a sub-location of the yard where soil concentrations are higher than the yard wide average.

The 90th percentile concentration is a conservative estimate of the mean of a sub-location.

EPC(subchronic) = 1.21 x 2.07 x EPC (bulk)

PAGE 56
SUBCHRONIC EXPOSURE ASSUMPTIONS

Variable	CTE	RME
EPC	2.5*EPC(bulk)	2.5*EPC(bulk)
Intake rate (mg/day)	200	400
Body weight (kg)	12.3	12.3
Exposure Frequency (days per month)	15	25
Averaging Time (days)	30	30
HIF (kg/kg-day)	8.1E-06	2.7E-05

Arsenic Toxicity Values

Toxicity Factor	Value	Source
Acute RfD	0.015 mg/kg/day	EPA OSWER (2001)
Acute RfD	0.005 mg/kg/day	ATSDR MRL
Subchronic RfD	0.006 mg/kg/day	EPA Region 8 (1995)

TABLE 4-3
ESTIMATED SUBCHRONIC NONCANCER RISKS FROM ARSENIC IN SOIL

Neighborhood	Number of Properties Evaluated	Number and Percent of Properties Within the Specified Risk Range							
		CTE Hazard Quotient				RME Hazard Quotient			
		<=1	2-5	6-10	>= 11	<=1	2-5	6-10	>= 11
Clayton	902	900	2			881	19	2	
		100%	0.2%			98%	2%	0.2%	
Cole	796	796	0			777	19	0	
		100%	0%			98%	2%	0.0%	
Elyria	59	59	0			58	1	0	
		100%	0%			98%	2%	0.0%	
Globeville	63	63	0			62	1	0	
		100%	0%			98%	2%	0.0%	
Swansea	1166	1166	0			1155	11	0	
		100%	0%			99%	1%	0.0%	
All	2986	2984	2			2933	51	2	
		100%	0.1%			98%	2%	0.1%	

Summary of Predicted Sub-Chronic Risks

- For **RME** scenario, there are **53 properties** where risks are unacceptable.
- At all 53 properties, the RME cancer risk is also greater than 1/10,000
- If cancer risk is addressed, sub-chronic risk will also be addressed

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ACUTE PICA EXPOSURE ASSUMPTIONS

Variable	CTE	RME
EPC	2.81*EPC(bulk)	2.81*EPC(bulk)
Intake rate (mg/day)		
Case 1	5000	10000
Case 2	2000	5000
Body weight (kg)	12.3	12.3

Exposure point concentration is the 95th percentile of the samples within the yard.

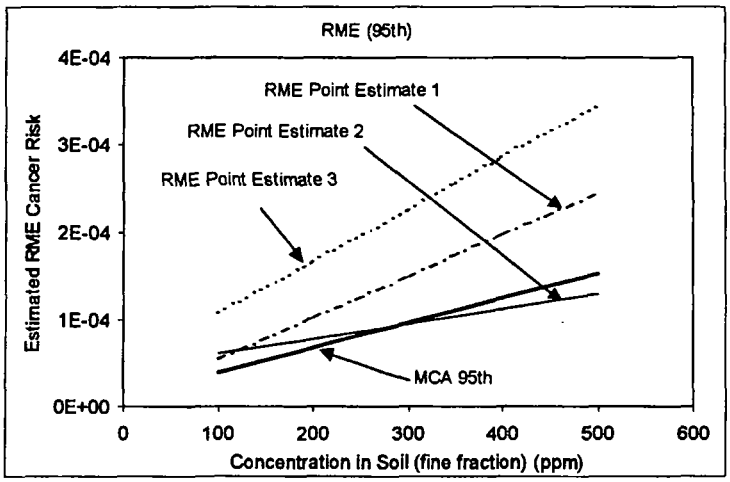
Summary of Predicted Acute Risks from Soil Pica Behavior

- For the **RME** scenario, there are **between 662 and 1841** properties where risks are **unacceptable.**
- For the **CTE** scenario, there are between **294 and 1511** properties where risks are **unacceptable**.
- Risk estimates are highly uncertain and are considered theoretical

TABLE 4-4
ESTIMATED ACUTE NONCANCER RISKS FROM PICA BEHAVIOR

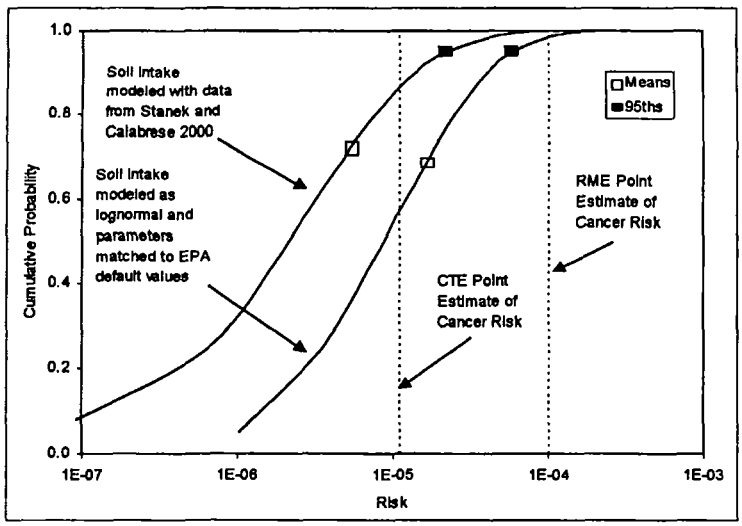
Exposure Assumptions	Number and Percent of Properties Within the Specified Risk Range									
	CTE Hazard Quotient					RME Hazard Quotient				
	<=1	2-5	6-20	>20	Total >1	<=1	2-5	6-20	>20	Total >1
Case 1	1475	949	482	130	1511	1145	580	328	933	1841
	49%	32%	14%	4%	51%	38%	19%	11%	31%	62%
Case 2	2692	268	26	0	294	2324	487	162	13	662
	90%	9%	1%	0%	10%	78%	16%	5%	0%	22%

FIGURE D-2 – PANEL B
COMPARISON OF POINT ESTIMATE AND MONTE CARLO RME ESTIMATE OF TOTAL RISK ACROSS A RANGE OF ARSENIC CONCENTRATIONS IN SOIL



Monte Carlo evaluation assumes soil intake is distributed lognormally with a mean of 100 mg/day and a standard deviation of 53 mg/day (95th percentile – 200 mg/day)

FIGURE D-1
MONTE CARLO RESULTS FOR EXPOSRUE TO ARSENIC IN SOIL/DUST
Concentration in Fine Fraction = 200 ppm



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CANCER RISK ESTIMATES FOR 200 ppm ARSENIC IN FINE SOIL

Method	Statistic	Soil Alone	Vegetables Alone	Total Risk
Point Estimate	RME cancer risk	1.00E-04	7.00E-05	1.00E-04
Monte Carlo (a) (see Appendix D)	90th percentile	1E-05 to 4E-05	9.00E-06	2E-05 to 5E-05
	95th percentile	2E-05 to 6E-05	1.00E-05	3E-05 to 7E-05
	99th percentile	5E-05 to 1E-04	3.00E-05	6E-05 to 1E-04
	99.9th percentile	1E-04 to 2E-04	8.00E-05	1E-04 to 2E-04

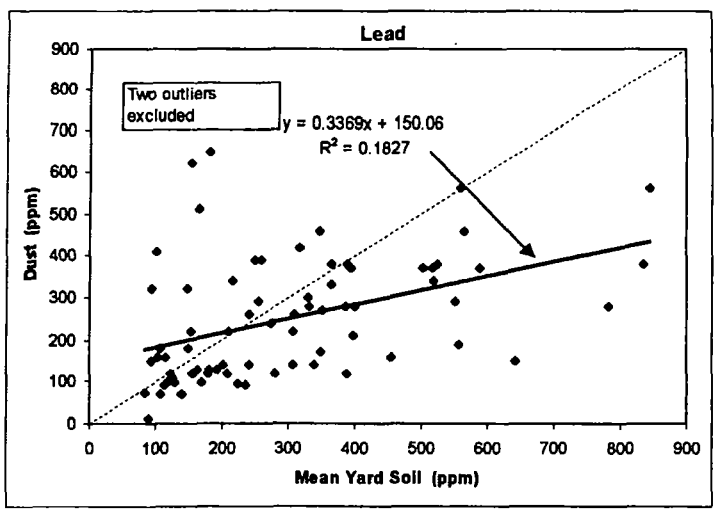
(a) Range is based on two alternative PDFs for soil intake rate (see Appendix D)

EXPOSURE AND RISK FROM LEAD

Site Specific Relationship Between Outdoor Soil and Indoor Dust

- Lead: Dust = 0.33 Soil + 150

FIGURE 2-9 – PANEL B
RELATION BETWEEN LEAD CONCENTRATIONS IN INDOOR DUST AND BULK YARD SOIL



Exposure to soil is suspected to occur mainly by ingestion of the fine fraction.

The value for the concentration of lead measured in the bulk fraction was adjusted to account for the enrichment of lead in the fine fraction compared to the bulk fraction:

Conc.(fine) = 1.09 x Conc.(bulk)

Relative Bioavailability of Lead in Soils at VB/170

- Site-specific RBA, measured in site soils, is 0.84

- The default assumption in IEUBK model is 0.6

FIGURE 2-11 – PANEL B
RELATION BETWEEN LEAD IN GARDEN SOIL AND YARD SOIL

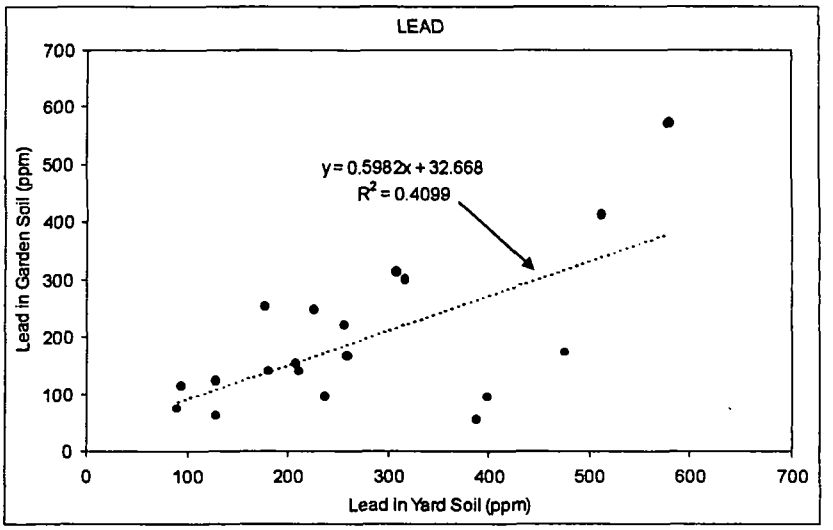
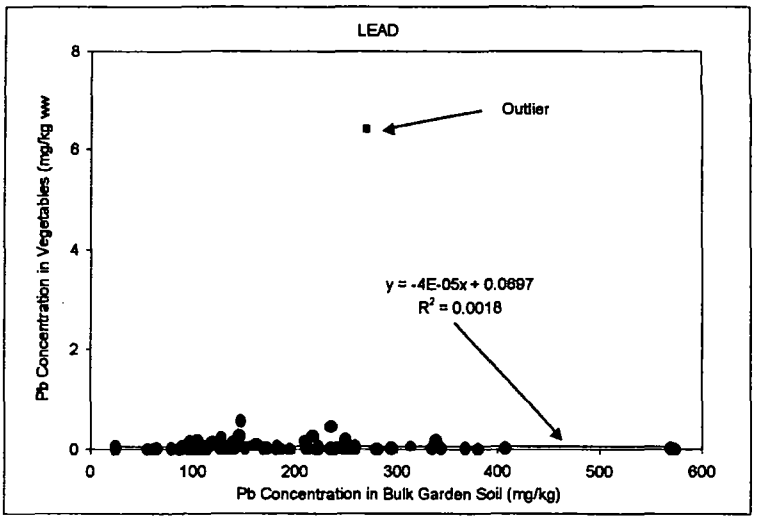


FIGURE 2-10 – PANEL B
RELATION BETWEEN LEAD IN GARDEN VEGETABLES AND GARDEN SOIL



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UNCERTAINTY ANALYSIS RESULTS FOR ALTERNATIVE IEUBK MODEL INPUTS

Model Run (a)	P 10 Value (%)				Total with P10>5%
	< 5%	5-10%	10-20%	> 20%	
Default (see Table 5-2)	1655	610	518	203	1331
Revised dietary intakes (see above)	1937	507	402	140	1049
GSD = 1.5	2058	450	345	133	928
GSD = 1.4	2413	315	171	87	573
Revised dietary intakes (see above) and GSD 1.4	2572	229	118	67	414
GSD = 1.3	2728	134	67	57	258
Revised dietary intakes (see above) and GSD = 1.3	2801	91	59	35	185
GSD = 1.2 (b)	2911	37	19	19	75
Revised dietary intakes (see above) and GSD = 1.2 (b)	2931	30	12	13	55
Soil intake based on Stanek and Calabrese (2000)	2986	0	0	0	0

(a) All runs include site-specific adjustments for lead enrichment in the fine fraction (1.09), RBA (0.84), and for soil-dust relationshi
(b) Calculations performed using the DOS version (0.99d) of the IEUBK model

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COMPARISON OF ISE AND IEUBK MODEL PREDICTIONS

Model Run	P 10 Value (%)				Total with P10>5%
	< 5%	5-10%	10-20%	> 20%	
IEUBK Model	1655	610	518	203	1331
ISE Model	2986	0	0	0	0

FIGURE 5-1 – PANEL A
STATE BLOOD LEAD ANALYSIS RESULTS
Blood Lead vs Soil Lead for all 3 Studies

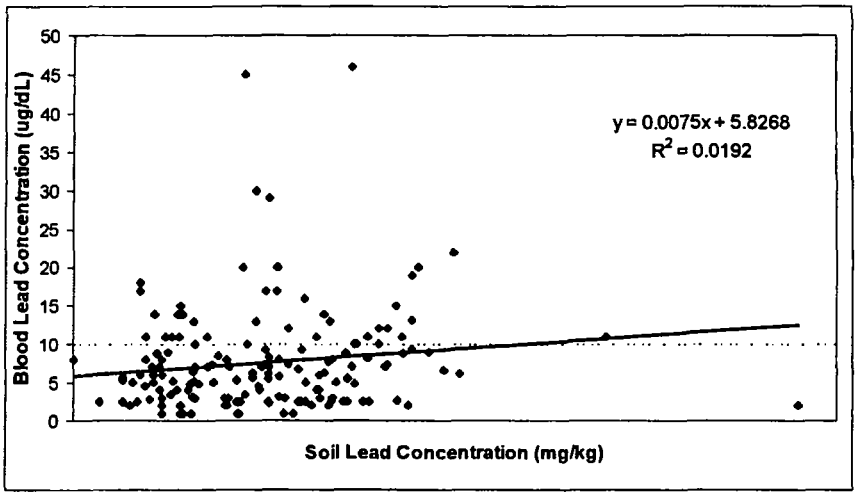
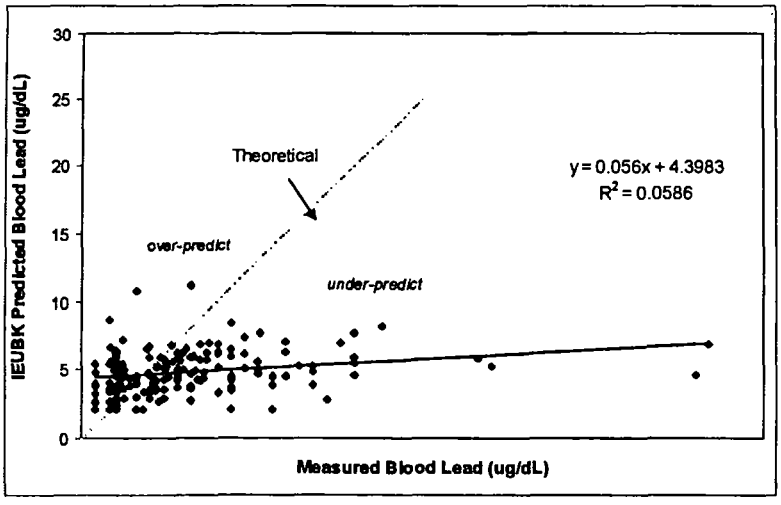


FIGURE 5-1 – PANEL B
STATE BLOOD LEAD ANALYSIS RESULTS
IEUBK Model Predicted Blood Lead vs Observed Blood Lead



Observations from Available Blood Lead Data

- Elevated blood lead levels occur in children residing within the VB/I70 Site
- Soil is not likely to be the main source of elevated blood lead levels
- Elevations are not clearly different from areas outside VB/I70

Observations from Available Blood Lead Data (cont.)

- Data was not sufficient to support a site specific value for the geometric standard deviation (GSD) of blood lead levels, a key parameter in the IEUBK model.

Feasibility Study

In the Feasibility Study, alternatives for managing the unacceptable risks are evaluated.

Remedial Action Objectives for Arsenic in Soil

- Prevent exposure to soil containing arsenic in levels predicted to result in excess lifetime RME cancer risk which exceeds 1/10,000
- Prevent exposure to soil containing arsenic in levels predicted to result in chronic or subchronic RME non-cancer hazard quotient which exceeds 1

Remedial Action Objectives for Arsenic in Soil (cont.)

- For children with pica behavior who live in VB/I70, reduce the potential for exposures to arsenic in soil that result in acute effects

At properties where yard EPCs are greater than **240 ppm**, the RME cancer risk is predicted to be greater than 1/10,000.

At properties where yard EPCs are greater than **47 ppm**, the RME acute risk to children with soil pica behavior is predicted to be unacceptable (hazard quotient is greater than 1).

Remedial Action Objective for Lead in Soil

- Limit exposure to lead in soil such that no more than 5 percent of young children are at risk for blood lead levels greater than 10 ug/dL from such exposure.

Lead Soil Levels at P10<5%
Alternative IEUBK Model Runs

GSD	Dietary Intake	Pb Soil Level
default	default	208
default	revised	246
1.4	default	326
1.4	revised	362
1.3	revised	443
1.2	default	542
1.2	revised	581

Components of the Community Health Program

- Designed to address risks to children from exposure to lead in soils and non-soil sources
- Designed to also address risks to children from potential exposure to arsenic associated with soil pica behavior

Components of the Community Health Program (cont.)

- Community and Individual Education and Outreach program
- Biomonitoring Program
- Response Program